Establishing a Chesapeake Bay Nontidal Watershed Water-Quality Network

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Prepared by the Chesapeake Bay Program's
Nontidal Water Quality Monitoring Workgroup

Chesapeake Bay Program

A Watershed Partnership

Executive Summary

The Chesapeake Bay Program has committed to meeting water-quality criteria (dissolved oxygen, water clarity and chlorophyll *a*) in the Bay and its tidal tributaries, by 2010. To achieve these criteria, the Chesapeake Bay Program's partners are implementing management actions, through the tributary strategy process, to reduce nutrients and sediments from entering the Chesapeake Bay watershed. The Chesapeake Bay Nontidal Watershed Water-Quality Network is a critical tool for measuring the nutrient and sediment concentrations and loads in the watershed and for assessing water-quality changes and progress toward meeting water-quality criteria in the Chesapeake Bay by 2010. Therefore, the Chesapeake Bay Program's Nontidal Water Quality Monitoring Workgroup is designing a network for the Chesapeake Bay watershed. The network is building from and integrating existing State and Federal (USGS and EPA) monitoring programs.

The objectives of the Chesapeake Bay Nontidal Watershed Water-Quality Network are to: (1) measure and assess the status and trends of nutrient and sediment concentrations and loads in the tributary strategy basins across the watershed, (2) help assess the factors affecting nutrient and sediment status and trends, and (3) improve calibration and verification of partners' watershed models.

The Chesapeake Bay Nontidal Watershed Water-Quality Network will be designed so that data are collected within tributary strategy basins and therefore, meet the objectives of the network. The goal is to have all stations meet the requirement for a "load" station. At a load station there will be a stream gage, 20 samples a year will be collected over a range of flow, including storms, and samples will be analyzed for total nitrogen, total phosphorus, and sediment. Since funding is currently not available to meet the requirements for load stations in all areas, some stations will initially be implemented to meet the minimum requirements to compute trends (stream-flow and monthly samples will be collected at these stations). The workgroup has agreed upon procedures to ensure data comparability between stations. The procedures include "routine" (monthly) samples and storm samples and laboratory analyses.

To develop a list of stations that would be included in the Chesapeake Bay Nontidal Watershed Water-Quality Network, existing stations were first evaluated to determine if they could be useful as part of the network. The Nontidal Water Quality Monitoring Workgroup developed a list of 188 candidate stations that included existing stations (115 stations) and locations where new stations (73) were recommended. The initial selection of stations in the network was focused on the streams/rivers draining the tributary strategy basin segments. Each jurisdiction prioritized stations in consultation with State Tributary Strategy Coordinators and the Chesapeake Bay Program's watershed monitoring and modeling staff. In total, 87 stations have been selected for implementation in order to meet the trend and load objectives of the network.

Multiple sources of funding will be needed to implement the network. However, the primary approach is to utilize and enhance existing water-quality monitoring and stream-gage programs. In general, a station in the network will cost about $45,000 a year to operate. With an initial network of nearly 100 stations, total operation cost per year will be near $4,500,000. The Nontidal Water Quality Monitoring Workgroup has been able to utilize existing ambient water-quality monitoring programs and stream gages to cover most of the network's implementation costs. Through discussions with EPA Regions 2 and 3 as well as each State's Water-Quality Program Coordinator, decisions were made to directly consider the Chesapeake Bay Nontidal Watershed Water-Quality Network as they revise their own water-quality monitoring strategies and networks that are funded with 106 grants. Additional funding was secured through the states abilities to shift some resources from other monitoring activities to the network, and through the Chesapeake Bay Program ($175,000) and the USGS ($100,000 one-time Congressional earmark).

To help implement the current stations and enhance the Chesapeake Bay Nontidal Watershed Water-Quality Network in the future, a Memorandum of Understanding will be signed by the States and Federal Agencies (EPA and USGS). As more stations are considered for the network, a similar strategy of utilizing multiple funding sources will be followed. Stations will be added to ensure that the network represents the different watershed characteristics and the range of nutrient and sediment sources.

Data from the Chesapeake Bay Nontidal Watershed Water-Quality Network will be interpreted to provide several "indicators" of water-quality conditions in the watershed. The indicators will be related to efforts to meet water-quality standards in the Chesapeake Bay by reducing nutrients and sediments in the Chesapeake Bay watershed. The "indicators" need to be used in conjunction with the Watershed Model Progress Runs, and the interpretation of tidal monitoring data, to provide a group of indicators that can be used to assess status and trends of water quality in the Chesapeake Bay and its watershed.

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Need for Network

The Chesapeake Bay Program partners have committed to meet Bay specific water-quality criteria (dissolved oxygen, water clarity and chlorophyll *a*) in the Bay and its tidal tributaries by 2010. Through the tributary strategy process, the Chesapeake Bay Program partners are implementing management actions throughout the six-state 64,000 square mile watershed to reduce nutrient and sediment loads in order to restore Chesapeake Bay water quality. The Chesapeake Bay Nontidal Watershed Monitoring Network is critical to measuring local stream and river ambient nutrient and sediment concentrations and loads to help track water-quality improvements and to progress toward meeting the resultant reduced loads from tributary strategy basins. Therefore, the Chesapeake Bay Program's Nontidal Water Quality Monitoring Workgroup is designing a network for the nontidal Chesapeake Bay watershed, building from and integrating existing State and Federal – U.S. Geological Survey (USGS) Environmental Protection Agency (U.S. EPA) – stream-flow gage and water-quality monitoring programs.

The existing monitoring programs do not necessarily meet the Chesapeake Bay restoration needs because they were designed separately by each agency for other purposes. For example, each State operates a stream water-quality monitoring program independently for its own objectives. Usually there is little coordination among the States and federal agencies doing monitoring in the watershed. As a result, there can be situations where two agencies monitor the same stream without knowledge of each other's efforts. In other cases, information can be lost for multiple jurisdictions when one agency makes a decision regarding termination of data collection on streams that extend across borders. Greater coordination of all nontidal monitoring in the Chesapeake Bay watershed is needed in order to improve efficiency for all jurisdictions. The Chesapeake Bay Nontidal Watershed Water-Quality Network, described above, will help provide the basis for that coordination.

Objectives of Network

The three primary objectives of the Chesapeake Bay Nontidal Watershed Water-Quality Network are to:

1) Measure and assess the status and trends of nutrient and sediment concentrations and loads in the tributary strategy basins across the watershed;
2) Assess the factors affecting nutrient and sediment status and trends; and
3) Improve calibration and verification of partners' watershed models.

In order to meet these objectives, data from the network will be interpreted to provide the Chesapeake Bay Program partners with the:

- Status of water-quality conditions in the watershed;

- Trends in nutrient and sediment concentrations and stream-flow at key stations in the tributary strategy basins characterizing loads from the upstream tributary strategy basin;

- Annual nutrient and sediment loads at a subset of these key stations;

- Information that can be used with other data to determine the factors affecting the observed trends in concentration and load;

- Information to improve calibration and verification of the partners' and individual jurisdiction's watershed models; and

- Indicators that can be used to communicate progress towards reducing load caps allocated to each tributary strategy basin, water-quality improvement in local streams and rivers, and progress towards meeting the basinwide cap load goal necessary for attaining water-quality standards in the Chesapeake Bay.

Station Requirements for Meeting Objectives

The Chesapeake Bay Nontidal Watershed Water Quality Network was designed so data are collected within individual tributary strategy basins to meet the objectives of the network. The goal is to have all stations meet the requirement for a "load" station, which requires high-flow data collection (see below). Since funding is currently not available to meet the requirements for load stations in all areas, some stations will initially be implemented to meet the minimum requirements for a "trend" station. These stations will be used to compute trends in concentration and flow. Data from both of these station types, and in particular load stations, will be used to improve watershed models. The load and trend data, along with data sets on nutrient and sediment sources, Best Management Practices (BMPs), land-use changes and watershed characteristics will be used to help assess the factors affecting local stream and river nutrient and sediment concentrations, flow and the resultant loads to downstream waters. The observed concentration/flow trends and calculated load data will help the tributary strategy teams to: 1) assess their progress toward meeting cap load allocations; 2) evaluate the effectiveness of the implementation of the tributary strategies to improve water-quality of local streams; and 3) determine if tributary strategy implementation in the watersheds will result in achievement of water-quality standards in the Bay.

Requirements for "Trend" Stations

Trend stations will generate the data necessary to determine if changes in in-stream nutrient and sediment concentrations are occurring over time. Trends will be determined for "flow-adjusted" concentration and stream/river flow. Having these two types of trends will provide information to help managers, scientists and tributary strategy stakeholders understand: 1) changes in stream-flow that are potentially due to land use changes; 2) changes in nutrient and sediment concentrations over time; and 3) the separate influences of hydrology and on-the-ground management actions on the observed water-quality changes. At least five years of monthly ambient concentration and stream/river data are needed to compute trends in concentration and flow.

To be included as a trend station within the basinwide network, a station must meet the following criteria:

1. The station must be associated with a stream-flow gage to allow computation of trends. Water-quality sampling must be conducted close to the stream-flow gage so that the water-quality and discharge information are comparable.
2. Samples need to be collected at least monthly over a five-year time span.
3. At a minimum, the samples should be analyzed for total nitrogen, total phosphorous and total suspended solids.
4. Samples should be collected using methods to ensure they represent water-quality conditions at the station.

Requirements for "Load" Stations

Load stations will generate the concentrations and flow data necessary to quantify the amount of nutrients and sediment leaving tributary strategy basins as loads to either the next downstream tributary strategy basin or to Chesapeake Bay tidal waters. Time series data records from these stations will also be used to calibrate watershed models. In order to compute loads, water-quality samples need to be collected over a range of stream/river flow (including storms) because of the change in concentration during storms. This is especially important for the phosphorus and sediment parameters. In addition to the water-quality samples, continuous stream/river flow data are needed to apply the statistical tools used to estimate stream loads. At least three years of concentration and flow data are needed to compute loads.

To be included as a load station within the network, a station must meet the following criteria:

1. The station must be associated with a stream-flow gage to allow computation of load (the product of flow times concentration). Water-quality sampling must be conducted close to the stream gage so that the water-quality and discharge information are comparable.
2. A total of 20 samples should be collected each year, including 12 monthly samples and eight storm samples based on an average flow year (the actual number of samples could be less during low flow years and more during high flow years as funds are available).
3. In general, the storm samples should attempt to target at least four different storms (one each season). More than one sample can be collected per storm but no more than one per day (this is a requirement of the statistical load estimation program).

4. At a minimum, the samples should be analyzed for total nitrogen, total phosphorous, ammonium, nitrate, phosphate and total suspended solids. Storm samples should also include suspended sediment and particle size.
5. For watershed modeling, it is recommended that samples also be analyzed for the recommended parameters list in Table 2.
6. Samples should be collected to ensure that they represent water-quality conditions at the station.

Station Selection Process

To develop the list of stations included in the Chesapeake Bay Nontidal Watershed Water-Quality Network, existing stations were first evaluated to determine if they would directly contribute to meeting objectives of the basinwide network. Stream-flow gage locations and water-quality stations were initially evaluated separately and then combined to search for stations where water-quality data were collected in close proximity to a stream-flow gage. The station selection process was used to determine which stations met the criteria described above for trend and load stations. The combination of existing stations that met basic trend or load criteria and proposed new stations provided a list of candidate stations. If all of the stations on the list were implemented, the stated network objectives and underlying management information needs would be met. Since funding is not currently available to support operation of all the candidate stations, they were prioritized for implementation during the initial year. Gaps in the coverage of that initial network were identified and new stations were proposed on the streams and rivers in those areas. The identified gaps helped to highlight a few of the remaining station selection issues.

Stream Gage Locations

Stream gages are usually established and operated by the U.S. Geological Survey (USGS) alone or through cooperative agreements. At each gage, continuous data records of stream-flow are collected and are often reported as mean-daily discharge (i.e. – in cubic feet per second). These data are used for various purposes depending on the gage, but are critical for estimating loads of water-quality constituents, calibrating watershed models and for understanding processes affecting water-quality. A full list of historical stream-gage locations was initially compiled from the USGS National Water Information System (NWIS) database. Stream gages were operated at 703 locations in the Chesapeake Bay watershed over some period of time in the historical record (1950-present). Of those, 319 were in operation in 2000 and were considered active for the purpose of the initial station screening (Figure 1).

The network of existing stream gages is quite valuable for the purposes of the Chesapeake Bay Nontidal Watershed Water-Quality Network. The operation of stream-flow gages represents a significant amount of the cost of monitoring at a load or trend station. Significant savings can be realized if the water-quality data collection can be added where an existing stream-flow gage is already funded and in operation. Thus, the population of existing stream-flow gages represents stations that can be monitored for loads and/or trends most cost effectively.

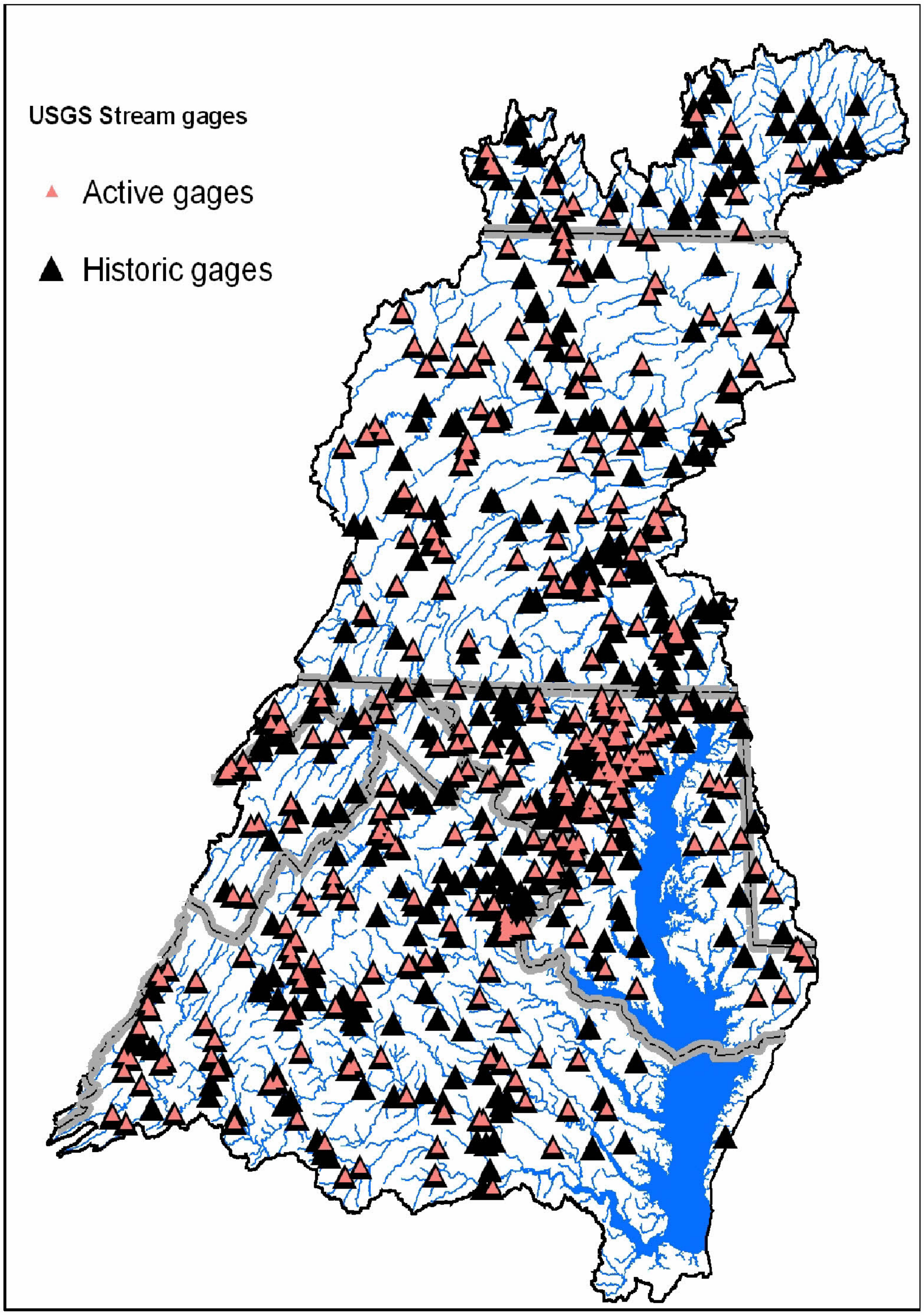

Figure 1. A total of 703 historical and 319 currently active stream gages have been operated by the U.S. Geological Survey in the Chesapeake Bay watershed since 1950.

Water-quality Monitoring Locations

Existing nontidal water-quality monitoring stations were initially compiled from a water-quality database that was developed for the Chesapeake Bay Program's Nutrient Subcommittee (Langland et al. 1995). The water-quality database includes data collected from more than 1,700 stations in the Chesapeake Bay watershed during the period 1972 to 2003. Many of the stations were sampled for less than the minimum three years and were eliminated from consideration. In many other cases, sampling ended long before the current time frame (1985 to present) and no recent data were available. A total of 641 stations were found be part of an active monitoring program in 2001 and were considered currently active (Figure 2).

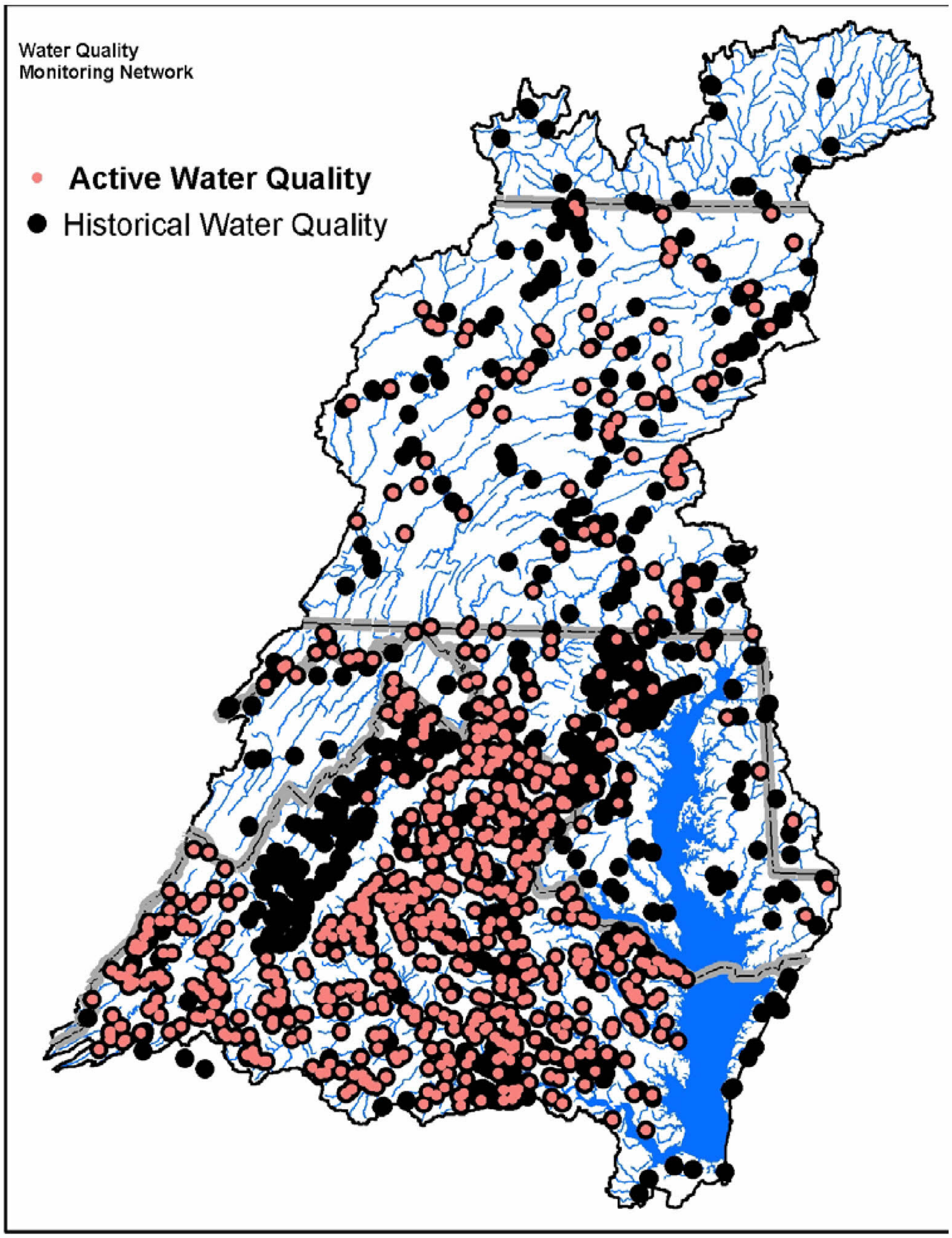

Figure 2. The locations of the more than 1700 historical and 641 currently active water-quality monitoring stations in the Chesapeake Bay watershed.

The second step of the screening process involved merging the list of existing water-quality monitoring stations with that of the stream gage locations, to determine how many of both station types were co-located (as defined by the network operators) (Figure 3). Of the 641 water-quality monitoring stations that were determined to be current, only 161 stations were co-located with a stream gage. In some cases, the locations of the water-quality sampling station and stream gage were separated by some distance, but were still considered as co-located by the agencies that conducted the monitoring. The distance separating the two types of data collection was sometimes substantial (i.e. – more than 10 miles), because of logistical factors that affect one or both of the two types of measurement. Spatial separation of where stream-flow is measured and water-quality data is collected can cause errors in load and trend assessment, if there are substantial differences in the drainage area characterized by the two stations. Each of the stations that are geographically separated was evaluated to see if they should be considered co-located. Once the list of co-located stations was defined, each station on the list was evaluated to determine if the sampling frequency and parameter criteria were met for the trend and/or load objectives.

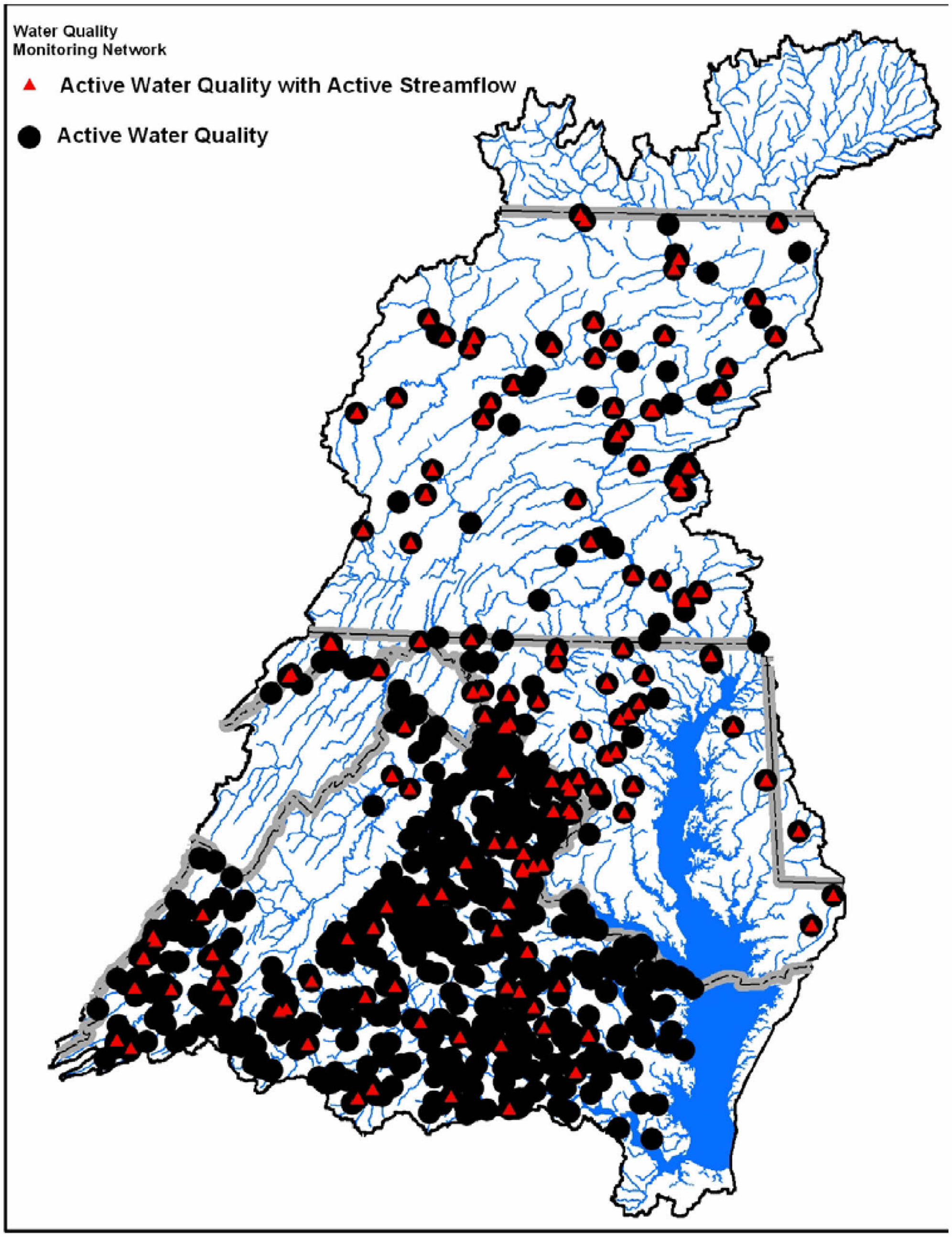

Figure 3. Active water-quality monitoring stations (n=641) and active water-quality stations that are co-located with a stream gage (n=161).

Evaluation Results

A minimal frequency criterion of 30 samples over three years was applied, with the idea that stations with that sampling frequency and data record could be upgraded with minimal effort. Usually a frequency of more than 30 samples over three years implies at least a monthly sampling program. Such monitoring would only require storm sampling to meet the load frequency criterion and would meet the trend frequency criterion if the sampling was continuous over a record length of five years. Stations that did not meet the minimal frequency criteria were usually those with semi-monthly sampling programs (i.e., 18 samples over three years). Of the 161 co-located stations, only 94 met minimal frequency -30 samples over three years- and parameter -total phosphorous and suspended solids- requirements (Figure 4).

As a final step, the Delaware, Maryland, New York, Pennsylvania, Virginia and West Virginia state water-quality management agencies were consulted, to determine if any changes in their networks occurred since the end of the period of the water-quality database (2000). A total of 21 additional stations were identified that were either started near the end of the period of record or were in the States of West Virginia and Delaware, which were not included in the original development of the data base. In all cases, those 21 additional stations were both co-located with a stream gage and met the minimal frequency and parameter requirements. Thus, there were a total of 115 existing stations that could be considered for the initial Bay Nontidal Watershed Water-Quality Network (Figure 4).

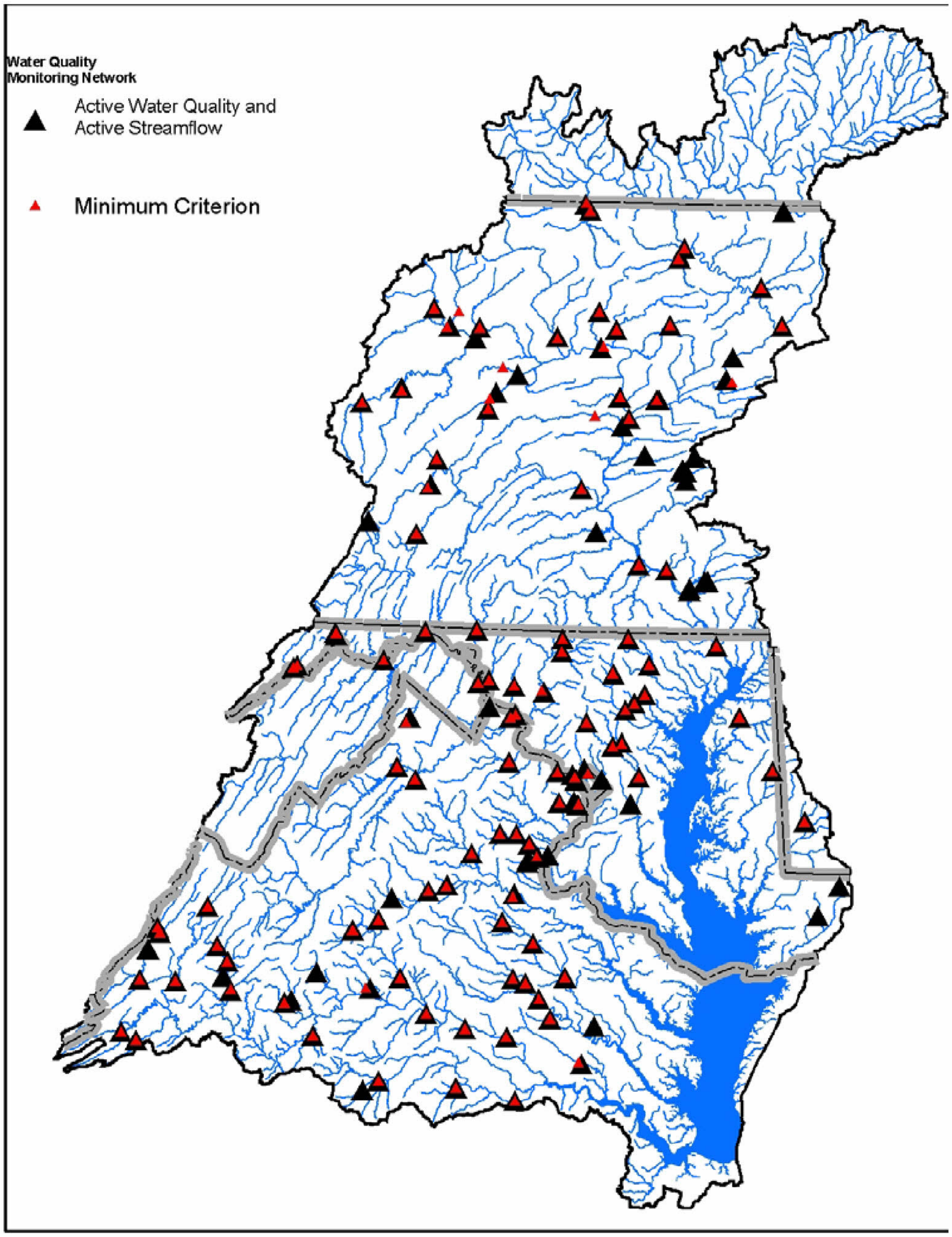

Figure 4. Locations of the 182 active water-quality monitoring stations that are co-located with a stream gage and the subset of 115 stations, which meet minimal frequency and parameter criteria.

New monitoring locations to address information gaps

The initial Chesapeake Bay Nontidal Watershed Water-Quality Network, based on existing stations, did not provide all of the information needed to meet the network's three primary objectives. Some tributary strategy basins were completely unrepresented while others did not have monitoring at the appropriate locations. To address these needs, new stations were proposed wherever the following types of stream locations were not monitored:

1. Outlets of major streams/rivers draining tributary strategy basins;
2. Areas within the tributary strategy basins that have the highest nutrient load delivery to the Chesapeake Bay and its tidal tributaries; and/or
3. Areas with relatively low density of monitoring stations.

Outlets of major streams/rivers were targeted in order to provide information regarding loading from tributary strategy basins and for tracking trends in water quality. Such information can be used to track progress in water-quality improvement as on-the-ground management actions are implemented. It should be noted that some tributary strategy basins are drained by multiple streams/rivers (e.g., western shore of the lower Susquehanna). In those cases, all streams/rivers with mean annual discharge above 50 cubic feet per second were targeted for monitoring. Areas that have the highest nutrient delivery to the Bay were targeted in order to track the areas with the greatest loads and, therefore, the greatest potential for load reduction. Areas of high loading were identified using the output from the USGS SPARROW nitrogen model (Preston and Brakebill, 1999), which provides consistent estimates of nutrient loading for the entire Chesapeake Bay watershed. Finally, areas of low monitoring density were targeted in order to identify previously unknown sources of nutrients and provide additional monitoring in the largest drainages for tracking local water-quality trends.

Using the three decision rules described above for identifying additional monitoring stations, 73 new stations were identified where monitoring information was needed to fully meet the basinwide network's three primary objectives. A total of 191 stations were identified as needed for the Chesapeake Bay Nontidal Watershed Water-Quality Network. All of these stations will provide data valuable for tracking progress within the respective tributary strategy basin. However, it was clear that funding would not be available for immediate operation and maintenance at all stations. The list of 191 stations was considered to be a list of candidate stations from which a subset would be selected for implementation (Figure 5). Each of the six watershed states was given the option to prioritize the candidate stations within its jurisdiction for implementation.

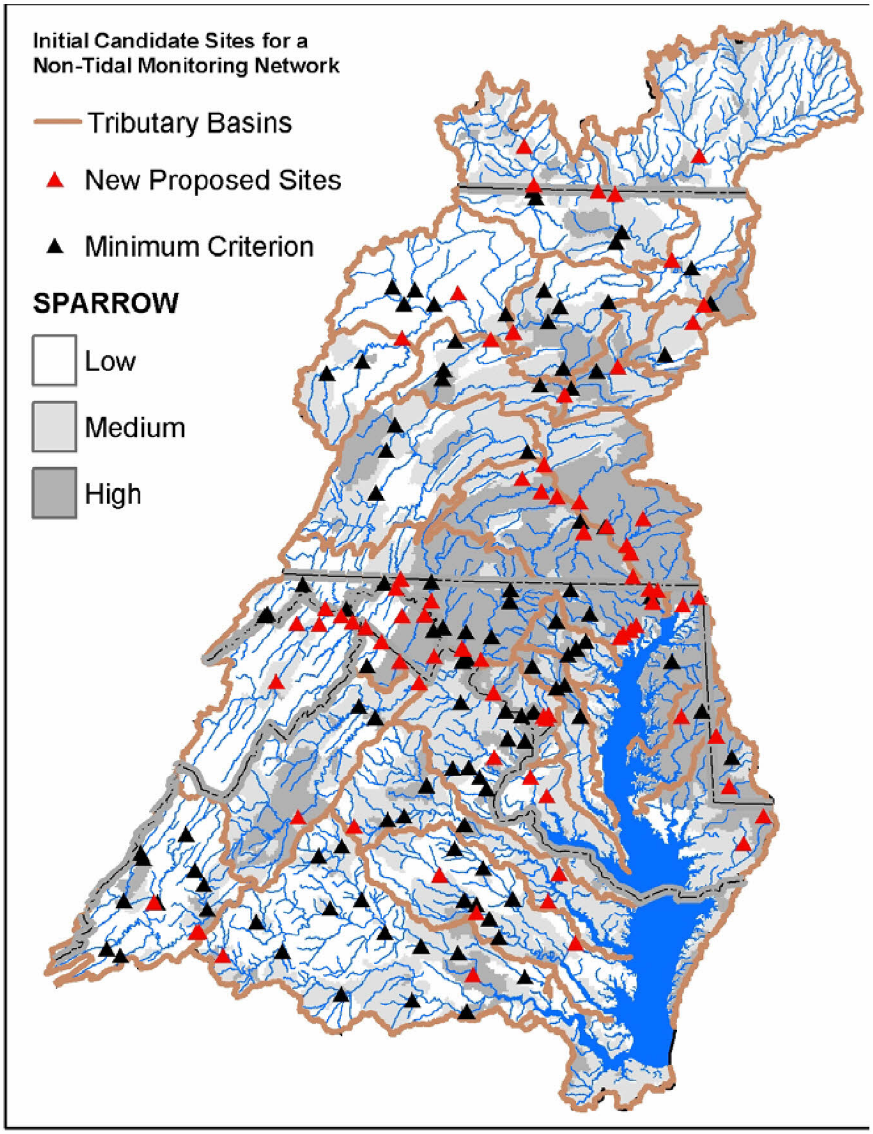

Figure 5. Existing and proposed new stations that form the list of "candidate" stations for inclusion in the Chesapeake Bay nontidal water-quality monitoring network. Tributary boundaries are shown. The areas of low, middle and high nutrient loading, estimated based on the USGS SPARROW model are indicated by the gray shading.

Remaining Network Station Selection Issues
The list of candidate stations primarily addresses the objective of measuring and assessing the status and trends of nutrient and sediment concentrations and loads in the tributary strategy basins. It is not known at this time how well the candidate stations specifically address the objective of improving the calibration and verification of partners' watershed models. To best support watershed modeling, selected stations should be fully representative of the range of geographic features such as land use, physiography and climatography. There has not yet been any evaluation of the representativeness of the candidate stations. To be fully supportive of the network's watershed modeling objective, an evaluation of the representativeness of the initial network is needed.

The initial network design was focused on addressing the more immediate management objective to track progress of load reductions to support tributary strategy efforts. The Chesapeake Bay Program's Nontidal Water Quality Monitoring Workgroup plans to evaluate the representativeness of the stations within the initial network design. Obvious gaps in representativeness will be addressed by changing the location of candidate stations or adding new stations to the initial network (based upon available funds) to better capture the geographic characteristics that are unrepresented.

Implementation of Network

Once the list of candidate stations was established, each State prioritized and finalized the stations that could be implemented within the available funding constraints. Several of the stations had limitations regarding their sampling and the resulting analyses. Therefore, in some cases, available funds were dedicated toward resolving these limitations within existing stations as opposed to establishing new stations.

Funding
Much of the water-quality monitoring is supported by U.S. EPA Clean Water Act section 106 funding. Because this data collection serves the broader needs of the States, there was limited flexibility to adapt these monitoring stations to also meet the basinwide network's objectives. However, each State reviewed its existing water-quality monitoring stations for any possible redundancies and inefficiencies. By shifting some of the existing water-quality monitoring activities, some 106 funds were made available to help support enhancements to other existing stations such as initiation of storm-event sampling or to help establish new stations.

Multiple sources of funding will be needed to fully implement the network, but the initial focus is on utilizing and enhancing existing monitoring programs. A station in the network would cost about $45,000 a year to operate. With an initial network of nearly 100 stations, total operation cost per year will be near $4,500,000. The network design is based on the utilization of existing ambient water-quality monitoring programs and stream gages to cover the majority of the implementation cost. In addition, the network design effort included discussions with EPA Regions 2 and 3, and State Water-quality Program Coordinators to directly consider the Chesapeake Bay Nontidal Watershed Water-Quality Network as the States revise their water-quality monitoring strategies funded by 106 grants.

Two new sources of funding were identified to help implementation. First, the USGS, through a congressional "earmark," allocated $100,000 to help support network implementation. It is unclear if these funds will continue in the future and so these funds were dedicated primarily toward the establishment of new stream gages, which would be a one-time cost. The second source of funding was from the Chesapeake Bay Program through the Monitoring and Analysis Subcommittee. The Chesapeake Bay Program allocated $175,000 to support State efforts to establish the needed monitoring. These funds were allocated among the States roughly by the amount of drainage area that each jurisdiction has in the Bay watershed. This funding allocation approach was considered equitable by the Nontidal Water Quality Monitoring Workgroup, since larger drainages would theoretically require more monitoring.

Each State representative on the workgroup was charged with the responsibility of selecting stations for implementation. The selections were made within the constraints of funding that could be made available through improving existing network efficiency and the new funds from the USGS and U.S. EPA Chesapeake Bay Program Office. Based on the work done by each State, 87 stations have tentatively been identified for implementation or enhancement to meet the network's load and /or trend objectives (Figure 6, Table 1). A small number of those 87 stations are still being evaluated to see if problems such as geographic separation between water-quality sampling station and stream-flow gage can be rectified. However, most stations are slated for full implementation beginning in October 2004.

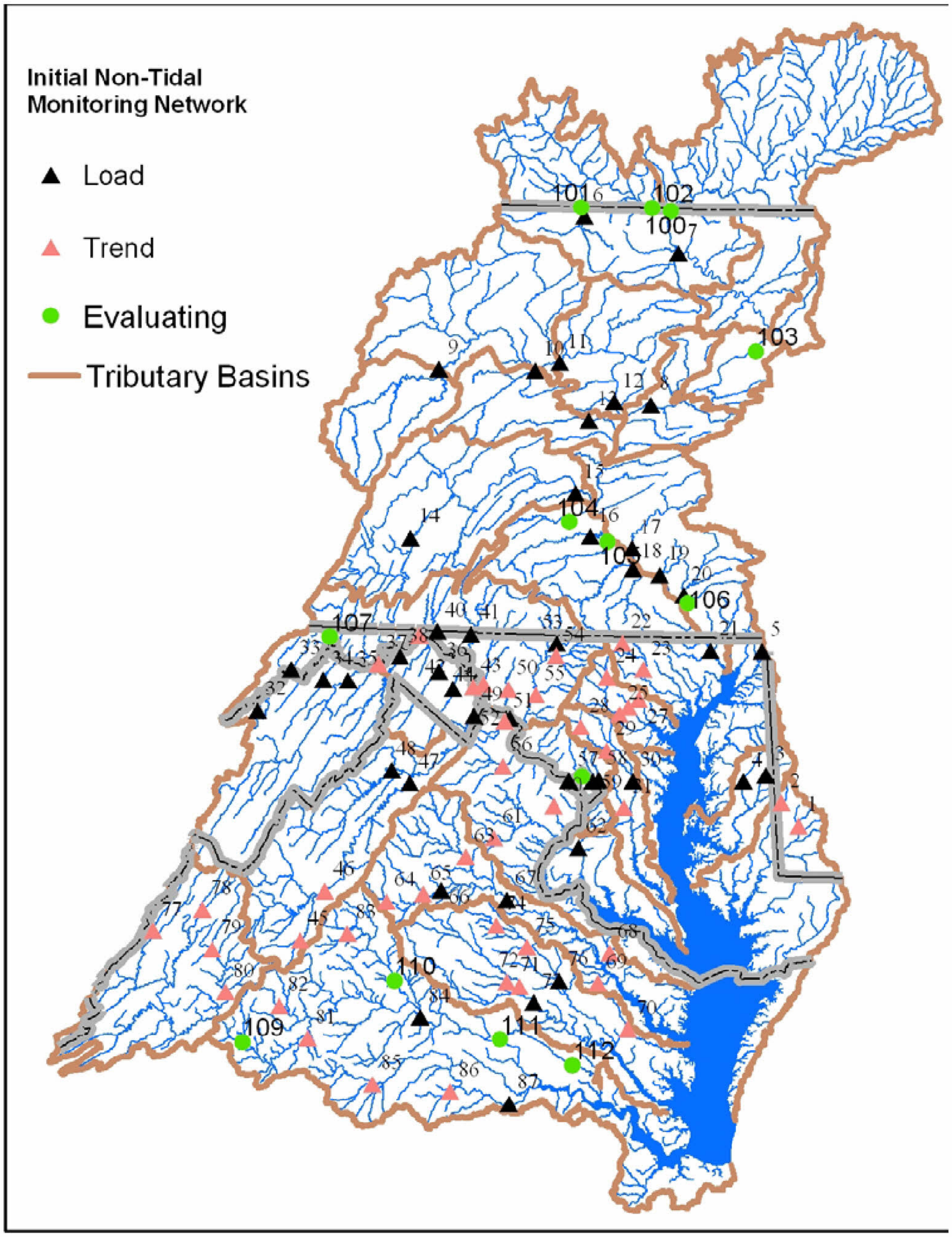

Figure 6. The 87 load and trend stations selected for initial implementation of Chesapeake Bay Nontidal Watershed Water-Quality Network. A subset of 13 stations are still being evaluated to determine if the water-quality monitoring can be co-located with the designated stream gage. The tributary strategy basins are shown to illustrate the network coverage for these basins.

Table 1. List of 87 stations selected for initial implementation of the Chesapeake Bay Watershed Nontidal Water-Quality Monitoring Network.

STATE	SITE NAME	MAP-ID	STREAM GAGE ID	WATER QUALITY ID	LOAD	TREND
DE	NANTICOKE RIVER NEAR BRIDGEVILLE	1	01487000	304191		X
DE	MARSHY HOPE CR	2	01488500	302031		X
MD	CHOPTANK RIVER NEAR GREENSBORO	3	01491000	01491000	X	X
MD	TUCKAHOE R	4	01491500	TUK0133	X	X
MD	BIG ELK CR	5	01495000	BEL0043	X	X
MD	SUSQUEHANNA RIVER AT CONOWINGO	21	01578310	01578310	X	X
MD	GUNPOWDER FALLS AT HOFFMANVILLE	22	01581810	GUN0476		X
MD	GUNPOWDER FALLS AT GLENCOE	23	01582500	GUN0258		X
MD	NORTH BRANCH PATAPSCO RIVER AT CEDARHURST	24	01586000	NPA0165		X
MD	PATAPSCO RIVER AT HOLLOFIELD	25	01589000	PAT0285		X
MD	GWYNNS FALLS AT VILLA NOVA	26	01589300	GWN0115		X
MD	JONES FALLS AT SORRENTO	27	01589440	JON0184		X
MD	PATUXENT RIVER NEAR UNITY	28	01591000	PTX0972		X
MD	PATUXENT RIV NEAR LAUREL	29	01592500	PTX0809		X
MD	PATUXENT RIVER NEAR BOWIE	30	01594440	01594440	X	X
MD	WESTERN BRANCH AT UPPER MARLBORO	31	01594526	WXT0045		X
MD	GEORGES CREEK AT FRANKLIN	33	01599000	GEO0009	X	X
MD	POTOMAC RIVER AT PAW PAW	37	01610000	POT2766		X
MD	POTOMAC RIVER AT HANCOCK	39	01613000	POT2386		X
MD	POTOMAC RIVER AT SHEPHERDSTOWN	43	01618000	POT1830		X
MD	ANTIETAM CREEK NEAR SHARPSBURG	44	01619500	ANT0044		X
MD	CATOCTIN CREEK NEAR MIDDLETOWN	50	01637500	CAC0148		X
MD	POTOMAC RIVER AT POINT OF ROCKS	52	01638500	POT1595	X	X
MD	MONOCACY RIVER AT BRIDGEPORT	53	01639000	MON0528	X	X
MD	BIG PIPE CREEK AT BRUCEVILLE	54	01639500	BPC0035		X
MD	MONOCACY RIVER AT JUG BRIDGE NEAR FREDERICK	55	01643000	MON0155		X
MD	POTOMAC RIVER NEAR WASH DC LITTLE FALLS PUMP	57	01646500	01646580	X	X
MD	NE BRANCH ANACOSTIA RIVER AT RIVERDALE	58	01649500	01649500	X	X
MD	NW BRANCH ANACOSTIA RIVER NEAR HYATTSVILLE	59	01651000	01651000	X	X
MD	MATTAWOMAN CR	62	01658000	01658000	X	X
MD	WILLS CREEK NEAR CUMBERLAND	107	01601500	WIL0013		X
MD	ROCK CREEK AT SHERRILL DRIVE WASHINGTON	108	01648000	RCM0111		X
NY	SUSQUEHANNA R AT WAVERLEY	100	01515000	-9999	X	X
NY	CHEMUNG R	102	01531000	-9999	X	X
PA	TIOGA RIVER AT TIOGA JUNCTION	6	01518700	WQN0324	X	X
PA	SUSQUHANNA RIVER AT TOWANDA	7	01531500	WQN0305	X	X
PA	SUSQUEHANNA RIVER AT DANVILLE	8	01540500	WQN0301	X	X
PA	SUSQUEHANNA R, W BR AT KARTHUS	9	01542500	WQN0404	X	X
PA	BALD EAGLE CR AT CASTANEA	10	01548085	WQN0445	X	X
PA	SUSQUEHANNA R W BR AT JERSEY SHORE	11	01549760	WQN0448	X	X
PA	WEST BRANCH SUSQUEHANNA RIVER AT LEWISBURG	12	01553500	WQN0401	X	X
PA	PENNS CREEK AT PENNS CREEK	13	01555000	WQN0229	X	X
PA	RAYSTOWN BRANCH JUNIATA RIVER AT SAXTON	14	01562000	WQN0223	X	X
PA	JUNIATA RIVER AT NEWPORT	15	01567000	WQN0214	X	X
PA	CONODOGUINET CR NEAR HOGESTOWN	16	01570000	WQNO271	X	X
PA	SWATARA CR NEAR HERSHEY	17	01573560	WQN0272	X	X
PA	WEST CONEWAGO CREEK NEAR MANCHESTER	18	01574000	WQN0210	X	X
PA	SUSQUEHANNA RIVER AT MARIETTA	19	01576000	WQN0201	X	X
PA	CONESTOGA CR NR CONESTOGA	20	01576754	WQN0273	X	X

Table 1. Continued

STATE	SITE NAME	MAP-ID	STREAM GAGE ID	WATER QUALITY ID	LOAD	TREND
PA	LICKING CR	40	01613500	WQN0509	X	X
PA	CONOCOCHEAGUE CREEK AT FAIRVIEW	41	01614500	WQN501	X	X
PA	COWANESQUE RIVER NEAR LAWRENCEVILLE	101	01520000	WQN0320	X	X
PA	SUSQUEHANNA RIVER NEAR WILKES-BARRE	103	01536500	WQN0302	X	X
PA	SHERMAN CR	104	01568000	WQN0279	X	X
PA	YELLOW BREECHES CR	105	01571500	WQN0212	X	X
PA	PEQUEA CR	106	01576787	WQN0204	X	X
VA	SOUTH RIVER NEAR WAYNESBORO	45	01626000	1BSTH027.85		X
VA	S F SHENANDOAH RIVER	46	01628500	1BSSF100.10		X
VA	S F SHENANDOAH RIVER AT FRONT ROYAL	47	01631000	1BSSF003.56	X	X
VA	N F SHENANDOAH RIVER NEAR STRASBURG	48	01634000	1BNFS010.34	X	X
VA	CATOCTIN CREEK AT TAYLORSTOWN	51	01638480	1ACAX004.57		X
VA	GOOSE CREEK NEAR LEESBURG	56	01644000	1AGOO011.23		X
VA	ACCOTINK CREEK NEAR ANNANDALE	60	01654000	1AACO014.57		X
VA	CEDAR RUN NEAR CATLETT	61	01656000	1ACER016.46		X
VA	RAPPAHANNOCK RIVER AT REMINGTON	63	01664000	3-RPP147.10		X
VA	RAPIDAN RIVER NEAR RUCKERSVILLE	64	01665500	3-RAP066.54		X
VA	ROBINSON RIVER NEAR LOCUST DALE	65	01666500	3-ROB001.90		X
VA	RAPIDAN RIVER NEAR CULPEPER	66	01667500	3-RAP030.21	X	X
VA	RAPPAHANNOCK RIVER NEAR FREDERICKSBURG	67	01668000	3-RPP113.37	X	X
VA	CAT POINT CR NEAR MONTROSS	68	01668500	3-CAT011.62		X
VA	PISCATAWAY CR NEAR TAPPAHANNOCK	69	01669000	3-PIS009.24		X
VA	DRAGON SWAMP AT MASCOTT	70	01669520	7-DRN010.48		X
VA	NORTH ANNA RIVER AT HART CORNER NEAR DOSWELL	71	01671020	8-NAR005.42		X
VA	LITTLE RIVER NEAR DOSWELL	72	01671100	8-LTL009.54		X
VA	PAMUNKEY RIVER NEAR HANOVER	73	01673000	8-PMK082.34	X	X
VA	PO RIVER NEAR SPOTSYLVANIA	74	01673800	8-POR008.97		X
VA	MATTAPONI RIVER NEAR BOWLING GREEN	75	01674000	8-MPN094.79		X
VA	MATTAPONI RIVER NEAR BEULAHVILLE	76	01674500	8-MPN054.17	X	X
VA	BACK CREEK NEAR MOUNTAIN GROVE	77	02011500	2-BCC004.71		X
VA	BULLPASTURE RIVER AT WILLIAMSVILLE	78	02015700	2-BLP000.79		X
VA	CALFPASTURE RIVER ABOVE MILL CREEK AT GOSHEN	79	02020500	2-CFP004.67		X
VA	MAURY RIVER NEAR BUENA VISTA	80	02024000	2-MRY014.78		X
VA	JAMES RIVER AT BENT CREEK	81	02026000	2-JMS229.14		X
VA	PINEY RIVER AT PINEY RIVER	82	02027500	2-PNY005.29		X
VA	MECHUMS RIVER NEAR WHITE HALL	83	02031000	2-MCM005.12		X
VA	JAMES RIVER AT CARTERSVILLE	84	02035000	2-JMS157.28	X	X
VA	APPOMATTOX RIVER AT FARMVILLE	85	02039500	2-APP110.93		X
VA	DEEP CREEK NEAR MANNBORO	86	02041000	2-DPC005.20		X
VA	APPOMATTOX RIVER AT MATOACA	87	02041650	2-APP016.38	X	X
VA	JAMES R	109	02025500	2-JMS279.41	X	X
VA	RIVANNA RIVER AT PALMYRA	110	02034000	2-RVN015.97	X	X
VA	JAMES RIVER NEAR RICHMOND	111	02037500	2-JMS117.35	X	X
VA	CHICKAHOMINY RIVER NEAR PROVIDENCE FORGE	112	02042500	2-CHK032.77		X
WV	STONEY RIVER NEAR MT. STORM	32	01595200	NB-SR1	X	X
WV	PATTERSON CR	34	01604500	NB-PC1	X	X
WV	POTOMAC R S BR	35	01608500	SOU0004	X	X
WV	BACK CR	36	-9999	PT-BC1	X	X
WV	CACAPON RIVER NR GREAT CACAPON	38	01611500	PC-000-006.0	X	X
WV	OPEQUON CREEK NEAR MARTAINSBURG	42	01616500	PT-OP2	X	X
WV	SHENANDOAH R	49	01636500	SR-SH3	X	X

Initial Evaluation of Existing Water-Quality Stations

Only the minimal frequency and parameter criteria were initially applied to the evaluation of stations. The intent was that selected stations could be upgraded to meet the load-station criteria. However, this initial evaluation approach identified several limitations of the existing stations. The limitations include:

1. The majority of existing stations do not collect samples during storms preventing proper determination of nutrients and sediment loads;
2. The samples at some stations are not analyzed for a complete list of parameters; and
3. The determination of sediment concentration is not consistent at many stations.

At the majority of existing stations samples are not collected during storms preventing proper determination of nutrients and sediment loads. Only a small number of stations have samples collected over a range of stream-flow conditions (including storms), which is needed to properly compute a load. This is particularly important for determination of total phosphorous and sediment loads. Additionally, some of the existing nontidal monitoring programs have recently decreased their sample collection to less than once a month. This decrease will impact the ability to compute and detect trends in concentration and flow.

Samples at some stations are not analyzed for total nitrogen and total phosphorous. Some nontidal monitoring programs are only sampling for one species of nitrogen, such as nitrate, and a total nitrogen value cannot be determined. At other stations, both total nitrogen and total phosphorous are not being determined. An assessment of the parameters being analyzed by each of the jurisdictions and Federal agencies is presented in Table 2.

The determination of sediment is not consistent at many stations. There are two measures of sediment being conducted in the Chesapeake Bay watershed: total suspended solids and suspended sediment. One study by Gray et al. 2000 has shown that at higher concentration levels, during storms or when sand is greater than 25 percent of dry mass, total suspended solids analysis does not provide an accurate measure of suspended sediment in a river. In addition, many nontidal monitoring programs do not sample during storm events when most sediment is in transport so sediment concentrations over a range of flow are not being collected at many stations in the watershed. Finally, during storm events some sediment in transport will also include sand in addition to silt and clay. A "sand-fine" or particle-size analysis to document the relative amounts of each is not conducted at the vast majority of stations in the watershed.

Development of Comparable Methods

A goal of the Chesapeake Bay Nontidal Water-Quality Network is to evaluate conditions across the watershed. Because the monitoring network is comprised of selected stations from eight different State and federal monitoring programs, it is important that the Chesapeake Bay Program is able to combine and interpret the data sets with a high degree of confidence. To achieve this, participating agencies will analyze a core set of parameters using comparable sample collection and laboratory analysis procedures, as well as comparable data submission and data management practices. The Nontidal Water Quality Monitoring Workgroup will continue improving the comparability and consistency of data collection activities as the network is implemented and refined.

Collection and Analytical Procedures

The Nontidal Water Quality Monitoring Workgroup has agreed on sample collection and laboratory analysis procedures that will ensure data comparability among all of the stations in the network. The procedures include: 1) "routine" (monthly) samples, 2) storm samples and 3) laboratory methods.

Environmental agencies collect routine surface water samples using two different approaches: either a grab sample is taken from the mid-channel of the stream, or several depth-integrated samples are collected across the stream and composited. The latter method is preferred because concentration gradients often occur vertically and horizontally across the channel. Grab sampling however, is less expensive.

Those agencies collecting grab samples will work towards collecting a depth-integrated sample from a well-mixed point in the stream. USGS will assist the states in assessing the sampling stations to evaluate the representativeness of their collection points.

Representative storm samples are critical for accurate sediment and total phosphorus load estimations. For storm event sampling, agencies have agreed to collect depth-integrated samples composited across the transect of a stream, following USGS guidelines. State agencies will either contract with USGS or the Susquehanna River Basin Commission to collect storm samples, or will work with USGS staff to develop comparable State procedures. It is expected that many of the stations will require an on-station review to determine station-specific procedures for obtaining representative samples.

The laboratory methods used by the eight agencies participating in the Chesapeake Bay Nontidal Watershed Water-Quality Network are listed in Table 2. The analytical methods for nitrogen, phosphorus and total suspended solids are comparable. For suspended sediment and particle size analyses (storm events only), agencies will either contract with the USGS Sediment Laboratory in Kentucky, or develop identical methods in their State laboratories. Semi-annual, inter-laboratory comparison samples will be tested by the laboratories to demonstrate the accuracy of their data and document the comparability of these methodologies.

Table 2. Sample collection and analytical methods of the participating agencies in the Chesapeake Bay Nontidal Water-Quality Monitoring Network.

I. Required Parameters	USGS River Input	SRBC	PADEP	VDEQ	MDNR	DNREC	WVDA	NYSDEC
Total Nitrogen	PN + TDN	alk. persulfate SM 4500-Norg D	alk. persulfate SM 4500-Norg D	alk. persulfate SM 4500-Norg D	TKN+NO23 351.2	TKN+NO23 351.2	TKN+NO23 351.1	TKN+NO23 351.2
Ammonium (dissolved)	90	350.1	350.1	(unfiltered) 350.1	350.1	350.1	350.1	350.1
Nitrate + Nitrite (dissolved)	353.2	353.2	353.2	(unfiltered) 353.2	(unfiltered) 353.2	353.2	353.2	353.2
Total Phosphorus	365.1	365.1	365.1	365.4	365.4	365.4	365.2	365.1
Phosphate (dissolved)	365.1	365.1	365.1	(unfiltered) 365.1	(unfiltered) 365.1	365.1		365.1
Total Suspended Solids	SM 2540 D	USGS-I-3765-85	USGS 1-3765	USGS-I-3765-85	SM 2540 D	160.2	SM 2540 D	160.2
Suspended Sediment (storms)	ASTM D3977C	X	X	ASTM D3977C	ASTM D3977C	N/A	ASTM D3977C	X
%Sand/Fine Particles (storms)	X	X	X	X	X	N/A	X	X
II. Recommended Parameters (for watershed model and source assessments)								
Dissolved Oxygen (field)	X		YSI meter	Insitu / minisonde	Hydrolab	360.1	SM 4500-O G	Hydrolab
Temperature (field)	X	Thermistor	Thermistor	Insitu / minisonde	Hydrolab	170.1	170.1	Hydrolab
Total Dissolved Phosphorus	365.1	365.1	365.1					
Total Dissolved Nitrogen	alk. persulfate	SM 4500-Norg D	SM 4500-Norg D					
Chlorophyll a (corrected)	SM 20th ed				SM 20th ed	SM 20th ed		
Total Organic Carbon (or PC)	(PC) 440.0	persulfate IR SM 5310D	persulfate IR SM 5310D		combustion IR SM 5310 B	415.1		
Dissolved Organic Carbon	UV persulfate/IR					415.1		
Volatile Suspended Solids	SM 2540			USGS-I-3765-85				
III. Sampling Design								
Number of Trend-only Sites	0	0	0	27	20	2	0	0
Number of Load/Trend Sites	9	6	21	11	10	0	7	2
Routine Sampling Frequency	12/yr.	12/yr.	12/yr.	12/yr.	12/yr.	12/yr.	12/yr.	12/yr. (6 SRBC)
Storm Sampling Frequency	10-20 days/yr.	8 days/yr.	8 days/yr.	8 days/yr.	8 days/yr.	N/A	8 days/yr.	8 days/yr.
Sample Type (routine)	cross section, depth integrated composite	cross section, depth integrated composite	depth integrated composite across transect	mid-channel, surface grab (bucket)	mid-channel, surface grab (bucket)	mid-channel, below the surface	mid-channel, mid-depth grab	cross section, depth integrated composite
Sample Type (storms)	depth integrated composite across transect (isokinetic)	depth integrated composite across transect (isokinetic)	depth integrated composite across transect	depth integrated composite across transect (isokinetic)	To be established	N/A	To be established	depth integrated composite across transect (isokinetic)

Abbreviations:

DNREC	Delaware Natural Resources and Environmental Control
MDNR	Maryland Department of Natural Resources
NYSDEC	New York State Department of Environmental Conservation
PADEP	Pennsylvania Department of Environmental Protection
SRBC	Susquehanna River Basin Commission
USGS	U.S. Geological Survey
VDEQ	Virginia Department of Environmental Quality

Data Submission and Data Management Procedures
The data collected as part of the Chesapeake Bay Nontidal Watershed Water-Quality Network will be added to the Chesapeake Bay Program water-quality database, which is part of the Chesapeake Information Management System (CIMS). These data will pass the same level of quality assurance used with the current Chesapeake Bay Program database and will be made available to the public through the CIMS "Data Hub" on the Chesapeake Bay Program website at www.chesapeakebay.net.

Data management for this project will have two phases. First, the nontidal SAS database (1970-2003), now in use for data analysis, will be reformatted and added to the Chesapeake Bay Program water-quality relational database. Then, SAS data prior to1984 will be reformatted after the 1984 through 2003 data are completed. This work will be completed at the Chesapeake Bay Program's Data Center in Annapolis, Maryland. Then, the 2004 and future monitoring data will be posted through a CIMS networked website or submitted electronically to the Chesapeake Bay Program on a yearly or more frequent, basis through either the Client to Access Web Service or the DUQAT Online Submission Tool.

Direct Data Submission:
DUQAT (Data Upload and Quality Assurance Tool) is the current tool for electronic data submissions to the Chesapeake Bay Program water-quality database. Using this method, the dataset must be formatted in ACCESS 97 tables and manually submitted to the online DUQAT software. The dataset is processed overnight, and a quality assurance report is available for the submitter to review the next day. After each dataset passes all the quality assurance checks and is approved by the Chesapeake Bay Program Water-quality Data Manager, it is added to the Chesapeake Bay Program water-quality database.

The data submission will be a database composed of three tables: 1) WQ_EVENT, 2) WQ_DATA and 3) WQ_CRUISES. The WQ_EVENT table describes information pertaining to the sampling event for each station and date; the WQ_DATA table contains the measured value and other information for each parameter at a particular station, date, and sample depth; and, the WQ_CRUISES table assigns a monitoring cruise ID to each monthly cruise or cruises and records the agency, program, project and the start and end dates for the cruise. The DUQAT software will run approximately 70 quality assurance checks on the submitted nontidal data. These checks include comparing database codes such as stations, parameter names, and methods to the database lookup tables.

Create Client to Access Web Service:
To use the second option, the Client to Access Web Service, the Chesapeake Bay Program Data Center staff will develop a web service that will accept and import data to the water-quality database. The web service is a self-describing, self-contained, modular unit of application logic that provides some business functionality to other applications through an internet connection. Applications access web services via web protocols and data formats, such as HTTP and XML, without respect to how each web service is implemented. There is not an associated web page, as the client application can use the

web service like a function. The data submitters will develop clients that will send data from their data holdings to the Chesapeake Bay Program web service. This option will require developing a client for each data submitter and a new web service. However, once these programs are in place, data will not have to be manually formatted and submitted to the Chesapeake Bay Program.

Currently, four data submitters are using one of these two options to submit tidal and nontidal monitoring data to the Chesapeake Bay Program. The Chesapeake Bay Program Office staff will work with the other data submitters to arrive at the most practical solution for data submission. The process of acquiring these data will be a collaborative effort between the submitter and the Chesapeake Bay Program. In addition, each data submitter will be responsible for the creation and yearly update of a metadata record using the CIMS Online Metadata Entry Tool (COMET).

The quality assurance checks run by the Chesapeake Bay Program web service will be limited to verifying that the data fit into the database without causing errors. There will be checks for duplicate records and for properly formatted XML files being sent to the Chesapeake Bay Program web service. The data submitter will be responsible for running their own in-house quality assurance checks prior to the transfer of these data.

Interpretation of Results from the Network

Data from the Chesapeake Bay Nontidal Water-Quality Network, which includes the river-input stations, will be processed to provide several "indicators" of water-quality conditions through the Chesapeake Bay watershed. All of the proposed indicators relate to meeting water-quality standards in the Chesapeake Bay through efforts to reduce nutrients and sediment loads from the watershed. The indicators that are being considered for interpretation of the nontidal water-quality data include:

1. Water-quality status.
2. Yield of nutrients and sediment.
3. Statistically defined temporal trend in stream-flow.
4. Statistically defined temporal trend in flow-adjusted concentration.
5. Graphical illustration of temporal changes in estimated load.

The importance of indicators for the water-quality status and yield of nutrients and sediments indicators is relatively straightforward. Trend in flow-adjusted concentration attempts to detect a trend in concentration by adjusting for the influence of flow and season. This indicator will be a valuable diagnostic tool to look at the change in concentration that would be due mostly to reduction of nutrient and sediment sources. Trends in stream-flow will also be an important diagnostic tool to assess its influence on concentration and load. Finally, changes in estimated load will be an indicator for annual delivery of load to the Chesapeake Bay and also change in load over time for selected stations in the watershed.

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